SYNOPSIS

Project Number: 02

Start: 06/01/94
End: 05/31/96

Title: Effects of Forest Understory Management on Stream Water Quality: Assessment of Natural Variation

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Focus Categories: WQL, NPP, ECL

Congressional District: Third

Descriptors: Water Quality, Watershed Management, Streams, Benthos, Bioindicators, Biomonitoring, Land-Water Interactions

A. Statement of the Water Problem and Research Objectives:

Little information is available about how forest thinning and burning practices affect physical, chemical, and biological water quality within watersheds of Alabama. My research consisted of a year-long, assessment of natural variation in water quality of three reference (i.e., unmanaged; ="C") streams within the Talladega National Forest, Alabama. Data from these reference streams are being used in combination with those collected from three separate, but managed (i.e., thinned and burned; ="Q"), streams within the Forest, part of a long-term experimental study funded by the U.S.D.A. Forest Service, National Forests in Alabama. Taken together, data from both managed and reference watersheds will allow a statistically rigorous analysis of effects of forest understory thinning and prescribed burning on stream water quality.

The specific objectives of the proposed research were twofold:

1. To quantify seasonal variation in physical, chemical, and biological water quality of three reference streams that drain undisturbed watersheds within the Talladega National Forest.

2. To use data from #1 together with those collected from three additional, but managed (i.e., thinned and burned), Talladega watersheds to elucidate the effects of forest understory management on stream water quality.
B. Explanation of Methodology

For each stream, attached algae (periphyton) and benthic invertebrates were sampled from five riffles distributed over a 0.5 - 1 km stream reach. Periphyton (algae) was sampled seasonally by placing unglazed quarry tiles (6" x 6", 232 cm²) on the bottom of each stream and allowing periphyton to colonize for 1 month. Benthic animals were collected with a Surber sampler (mesh size 250 μm). Organisms were identified to the lowest possible taxonomic level and watershed- and treatment-specific mean periphyton and animal richness and density were determined, and ultimately will be used as response variables in statistical analyses for the longer-term experiment.

In addition to sampling periphyton and animals the following stream chemical and physical parameters were monitored approximately monthly at each site: (1) Chemical: dissolved oxygen, specific conductance, calcium and magnesium hardness, total alkalinity, pH, phosphorus, nitrogen, free CO₂, chloride, and sulfide; (2) Physical: current velocity, maximum stage height, discharge, mean daily water temperature, substrate size and embeddedness, total suspended and dissolved solids, turbidity, stream width and depth, riparian shading, and particulate organic matter.

For the longer-term project, efforts are being made to characterize three different management levels that occur within managed streams: (1) pre-management; (2) post-thinning but pre-burning; and (3) post-thinning and burning. This will facilitate analyses of differences in time within managed watersheds (i.e., difference in means between pre- vs. post thin/burn) as well as between management treatments at the same time (i.e., differences in means between post thin/burn vs. reference streams), using ANOVA, multiple regression and other techniques.

C. Principal Findings and Significance:

The six streams showed little difference in most chemical and physical water quality attributes. Stream channels at baseflow were small (< 1.5 m) and stream water is well oxygenated (> 7 mg/l), circumneutral (pH: 6.0-7.0), clear (turbidity < 3.0 NTU), and low in suspended materials (Total solids: < 35 mg/l; conductivity: < 30 μmhos/cm² @ 25°C; total hardness and alkalinity: < 30 mg/L as CaCO₃; N and P: < 0.2 mg/L, J. Feminella, unpublished data). There were some notable differences among streams in basin area, channel gradient, annual temperature range, and mean riffle velocity, but all streams showed similar elevation, mean annual temperature, riparian shading, and substrate features.

Hydrologic profiles and historical (26-year) rainfall data indicated that the six streams differed along a gradient of flow permanence: 2 were normally intermittent (i.e., riffles ceased flowing in normal rainfall years) in summer, 1 was rarely intermittent (i.e., normally perennial), and 3 streams were occasionally intermittent (i.e., riffles ceased flowing during dry years).
Surprisingly, despite large differences in flow permanence among streams, invertebrate assemblages differed only slightly. Presence-absence data revealed that > 70% of the invertebrate species (178 total taxa, predominantly aquatic insects) were ubiquitous across the 6 streams. Although somewhat variable, many of the community richness and diversity measures were positively correlated with stream permanence. Year-to-year differences in communities within single streams appeared as great as differences between streams of contrasting permanence within a given year. Faunal similarity among streams was higher in 1995, a year with normal summer rainfall that followed a wet year (1994) than in 1994, a wet year that followed a dry year (1993). Between-year differences in density and richness were lowest in spring and winter and greatest in summer, the season when communities were directly exposed to drying of riffles in intermittent streams. These data in general support the hypotheses that 1) benthic invertebrate communities show predictable, albeit subtle, relationships with stream permanence, and 2) antecedent hydrologic conditions associated with riffle permanence, perhaps because of their effects on survival and recruitment of subsequent generations, can affect year-to-year variation in biological water quality attributes in streams. Preliminary data analyses suggest that forest thinning had no measurable effects on benthic macroinvertebrates (J. Feminella, unpublished data).

Analysis of periphyton data is on-going but some preliminary findings are noteworthy. Periphyton biomass (as ash-free dry mass) was generally higher in summer than spring, and was significantly higher in ‘Q’ streams in which understory thinning occurred than control ‘C’ streams that received no forest management. Although these data are preliminary, they are compelling in that they suggest understory thinning and its associated factors may have positive effects on the abundance and species composition of stream periphyton.

D. Publications and Presentations

Publication:

Presentations: